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REMARKS

Entry of the foregoing amendments, and reconsideration and reexamination of the subject application, as amended, are respectfully requested.

Amendments

Claim 1 has been amended to include essentially claim 9, directed to a fuel composition having both fuel and fuel additive. The transitional phrase has been amended to "consisting essentially of" to exclude components in the cited art that would be detrimental to a liquid hydrocarbon fuel, such as the aqueous ingredients of El A'mma. The specification discloses "liquid hydrocarbon fuels" (e.g., page one, line nine) such as gasoline (Example 2), diesel (Example 1), and heating oil (page seven). The dependent claims have been amended accordingly.

In addition, a range has been added to claim 1 where the composition has shown unexpectedly improved results (see the declarations submitted herewith and discussed below). 1:900 is about 0.00777 and 1:1300 is about 0.00077; Example 2 describes 2 oz. to 10 gal., which is about 0.00156 (about the middle of the claimed range), and which is within the broad range disclosed.

New claim 15 is analogous to existing claims 10 and 11, and raises no new issues.

Claim 12 has been amended also, including reciting improved combustion, as suggested in the Office action.

Declaratory Evidence

Submitted herewith are declarations by Jamie Ryder and Frank Norman explaining testing results using the instant composition in the amounts now claimed.

The Ryder declaration describes the use of the additive in combination with No. 6 heating oil for a high pressure industrial boiler. As shown therein, amounts tested within the range of 1:891 and 1:1312 showed improved combustion of the fuel, evidenced by an improved Steam:Fuel ratio, whereas amounts of about 1:600 and of about 1:1900 showed a decreased Steam:Fuel ratio.

The Norman declaration includes a copy of a report by the University of Southern Main to Mr. Norman on testing of the additive in automobiles. The amount tested, 2 oz. in 10 gal., is 0.0015625, about the midpoint of the range now claimed (as in Example 2). The Norman declaration also avers that he supplied both of the testing facilities (Irving Tanning Co., where Mr. Ryder is employed, and the University) with the composition, and the specific composition of the additive supplied to both facilities. (It also explains that he owns the BORGASM registered trademark by which the University referred to the fuel additive tested.)

Rejection

The rejection states that the previous claim was examined as a composition, without weight given to the intended use, and that the claims were not directed to a method for improving combustion. Claim 12 as amended now specifically recites a method for improving combustion, and, as with claim 1 as now amended, also requires that the additive be present in an amount relative to the amount of fuel effective to improve combustion of the fuel. None of the cited

art describes that the amount of additive is important for achieving more efficient fuel use.

Further, the patentability must be based not just on any similarity of the formulation in the prior art, but also the properties of the formulation. *In re Papesch*, 315 F.2d 381, 137 USPQ 43 (CCPA 1963). The enclosed article from Pall Corp. via the Internet (as reprinted from *Hydrocarbon Processing*) notes “a big problem” because “[w]ater concentrations as low as 100 ppm can cause off-specification due to haze, color or overall water concentration.” Thus, liquid hydrocarbon fuels contain negligible, if any water. In contrast, Zhan is directed to *replacement* fuels that contain significant amounts of water; and El A’mma’s compositions are for an aqueous environment. Hence, the “consisting essentially” language is intended to exclude water and essentially water-soluble (hydrophilic) compounds. The “amyl alcohol” forming most of the Zhan composition has solubility in water (and vice versa), which is why his compositions can include both amyl alcohol and water.

The entire thrust of applicant’s invention and disclosure is related to gasoline, diesel, and the like, and not the aqueous compositions in the cited art, which in the respect of being aqueous is non-analogous. It is for this reason that the instant amendments were not made earlier and are presented now.

The rust and corrosion inhibitors of Gallacher are provided as spreadable compositions, because the carriers include mineral oil, mineral spirits, and waxes (bottom of column five), and the amount of carrier is less than about 50% of the composition (col. 6, ln. 20-25; although the opposite is also disclosed). The Gallacher composition is applied to a metal surface (col. 3, ln. 63-64), not diluted at the amounts recited in the claims (including original claims 9 and 14). Further, the composition is applied to a metal surface and the surface then exposed to an environment normally sufficient to generate rust and corrosion.

Thus, the Gallacher composition is designed to stay on the surface and be non-reactive. All of the testing examples in Gallacher involve subjecting the composition to elevated temperature (e.g., 150°-200° C) and observing loss of sulfonate from the “painted” composition. While some of the possible carriers include materials, like kerosene, that can be used as fuels, no one would store a fuel like kerosene (or gasoline, or diesel) at such elevated temperatures.

Gallacher is directed to applications such as lubricating oils and greases (col. 1, ln. 20-21). Merely because Gallacher uses a carrier that could be (or is) used as a fuel does not provide motivation for using any of the compounds described therein as fuel additives. Accordingly, there is no motivation to use any of the compounds in Gallacher in a combusted fuel.

The abstract of Zhan is somewhat confusing, but it is noted that “[a] fuel composition for gasoline engines” includes 1-3% peroxide, whereas the claimed range is 0.125% (1:800) down to 0.07% (1:1400) additive. Zhan’s other disclosure, of 0.1-3% peroxide is mostly in a range that the attached declaratory evidence shows actually makes combustion worse (although such a composition is still combustible). Thus, Zhan does not appreciate the range required to improve fuel combustion. Rather, Zhan discloses a fuel substitute because his compositions contain mostly fusel oil (essentially amyl alcohol). There is no disclosure of actually using gasoline (claim 10), diesel (claim 11), or heating oil (claim 15); the fuel are disclosed as useful for “gasoline and diesel engines.”

Still further, and consonant with the instant amendments, the peroxides in Zhan are hydroperoxides, as are those in El A’mma (col. 3, ln. 38). Hydroperoxides are not lipophilic and so would not be suitable for use in applicant’s non-aqueous composition.

The statement in the rejection that “El A’mma is cited for teaching that the peroxides disclosed in Zhan are equivalent oxidants to those of the present

invention" is not rationally based on the respective disclosures, as El A'mma is directed to microbicides and Zhan is directed to fuel replacements. While the peroxide moiety is common, there is no disclosure or suggestion that a hydroperoxide useful for its microbicidal properties (El A'mma) in an aqueous solution would be useful for combustion in a fuel substitute (Zhan) (other than as a microbicide for the fuel). *In re Vaeck*, 947 F.2d 488, 493, 20 USPQ2d 1438, (Fed. Cir. 1991) (citing *In re Dow Chem. Co.*, 837 F.2d 469, 473, [5 USPQ2d 1529 (Fed. Cir. 1988)); both the suggestion and the reasonable expectation of success "must be founded in the prior art, not in the applicant's disclosure." Thus, the mere presence of a peroxide moiety is insufficient to warrant the combination, especially given that El A'mma's peroxides are hydroperoxides because they must be soluble in an aqueous environment.

In conclusion, the claims as amended clearly distinguish the cited art. The fuel consists essentially of a hydrocarbon fuel to avoid the presence of water, which is industry-recognized as a contaminant of the fuels disclosed in the specification, and by necessity the claimed peroxide and sulfonate must be soluble in such an environment for the additive to mix with the fuel. In light of the foregoing amendments and remarks, withdrawal of the rejections, and further and favorable action, in the form of a Notice of Allowance, is believed to be in order, and such actions are earnestly solicited.



IN THE UNITED STATES PATENT & TRADEMARK OFFICE

Appln. Ser. No.:	Filed:	Inventor(s):	Atty Dkt:
10/073,448	11 Feb. 2002	F. Norman	102FN-001A
Title: Fuel Additive Containing Lithium Alkylnaromatic Sulfonate and Peroxides			
Examiner: Cephia D. Toomer	Art Unit: 1714		

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION OF FRANK L. NORMAN

Dear Sir:

In connection with the subject patent application, I hereby declare as follows:

1. My name is Frank L. Norman, the sole inventor of the patent application identified in the caption. I was awarded a B.A. in Chemistry from Lafayette College. After serving in the United States Army, I worked in various chemical companies (Union Carbide, Pennwalt, ARCC), among other employment, before starting my own companies.
2. On March 24, 2003 I contracted with the University of Southern Maine to run 10 sets of data on vehicles using a composition described in my patent application. The final report ("USM Report") was rendered on 12-31-03 and was sent to me; a copy of that report is attached. The report showed an overall increase of 8.9% in miles per gallon in a mixed fleet of 7 vehicles.

10/073,448

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102FN-001A

3. The BORGASM fuel additive mentioned in the USM Report is my fuel additive. My company, Future Fuel Technologies, is the owner of U.S. Trademark Reg. No. 2,673,141 for BORGASM for "chemical additives for fuel treatment."
4. The BORGASM fuel additive composition that I provided to USM for use in generating the USM Report, and the additive provided to Irving Tanning Co. for use in the experiments described in the declaration by Jamie Ryder, were both provided by me and contained 35 % of lithium dodecylbenzenesulfonic acid, 6 % of t-butyl peroxide, and 3 % of MEKP.
5. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.



Frank L. Norman

8/2/04
Date

10/073,448

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PRELIMINARY TEST RESULTS FOR FUTURE FUEL TECHNOLOGIES, INC.

PRODUCT BORGASM FUEL ADDITIVE – MILEAGE ENHANCEMENT PRODUCT

MANUFACTURING APPLICATIONS CENTER
PRODUCT TESTING LAB
DR. WILLIAM H. MOORE, DIRECTOR
UNIVERSITY OF SOUTHERN MAINE
GORHAM, MAINE

MAY 29, 2003

PRELIMINARY TEST RESULTS

Overview

As of the date of this report, five randomly selected vehicles have been studied and their fuel mileage calculated both before (i.e., baseline) and after using the Borgasm additive at a ratio of 1 ounce additive per each 10 gallons of gasoline.

The table below identifies the vehicle with engine size, the baseline without additive, and the difference in results with the additive. In all cases, each vehicle had a minimum of five tankfulls/fillips of fuel consumed during each phase of the test.

VEHICLE IDENTIFICATION RESULTS TABLE			
Vehicle Identification	Baseline Mileage without Additive	Mileage with Additive	% Difference
8 cylinder, 14 passenger van, #19	15.72 mpg	16.9 mpg	7.5%
8 cylinder, 14 passenger van, #17	15.32 mpg	16.89 mpg	10.3%
8 cylinder, 14 passenger van, #22	14.59 mpg	16.54 mpg	13.4%
6 cylinder mini-van	21.38 mpg	23.74 mpg	11%
8 cylinder Jeep	13.75 mpg	14.42 mpg	5%

Additional vehicles are being tested at the present time, and results will be calculated as the data is collected.

Examiner: Dr. William H. Moore



THE UNITED STATES PATENT & TRADEMARK OFFICE

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Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION OF JAMIE RYDER

Dear Sir:

In connection with the subject patent application, I hereby declare as follows:

1. My name is Jamie Ryder. I am the Chief Engineer at Irving Tanning Co., Hartland, ME. I earned a State of Maine 2nd Class Engineer License, which is required for running high pressure equipment. I was awarded an A.S. degree from Husson College, Bangor, Maine, in 2003.
2. My responsibilities at Irving Tanning Co. include oversight of a high pressure boiler system, which is a closed loop system providing steam to various plant loads. These loads include heating process water to 170°F (250,000 gal/d; roughly 40% of the total load), process steam for drying and vacuum (roughly 30% of the total load), and facilities heating (roughly 15% of the load); the system is about 10% inefficient.
3. The usual method employed at Irving Tanning Co. for evaluating fuel costs for the boiler system is a calculation of the ratio of the pounds of steam produced to the gallons of fuel used. Steam is produced at

saturation at 70 psi, and the fuel is No. 6 fuel oil. This type of oil is a thick, viscous tar-like liquid made by blending heavy residual oils with a lighter oil (often No. 2) to obtain a specified viscosity and pour point; its specific gravity can vary from 0.95 to 1.03, and it must be heated to flow. Also, the content of various constituents (such as vanadium and sulfur) varies with each batch of oil delivered.

There is an 800 HP Cleaver-Brooks boiler at the facility that includes a "fuel treatment" system that accommodates the addition of additives to the fuel just prior to the burner gun.

The boiler system runs for 24 hours a day, seven days a week.

4. Under my direction and control, an additive supplied by Frank Norman was tested to determine whether the additive would provide any improvement in the steam:fuel (S:F) ratio. To make mixing easier and more homogeneous, the additive was mixed with No. 2 fuel oil (as a vehicle) prior to being mixed with the No. 6 fuel oil via the fuel treatment system.

Three sets of tests were conducted.

The first tests were conducted during four consecutive days in the fall of 2003. These results are shown in the following table, where the amount of fuel and additive are in gallons, and the steam produced is in pounds. As mentioned above, the boiler runs for 24-7, so the amount of fuel oil, additive, and steam are those generated in a 24 hour period. The "% ±" is based on using an average of days 1 and 4 as a baseline.

Day	No. 6 / Additive / No. 2	# Steam	S:F	% ±	Additive:No. 6
1	1900 / 0 / 0	264,860	139.4	n/a	n/a
2	2710 / <2.5 / <2.5	386,740	142.7	2.31	> 1:1084
3	2390 / >2.5 / >2.5	366,090	153.18	8.99	< 1:1084
4	1830 / 0 / 0	253,090	138.3	n/a	n/a

Later in the fall of 2003, with colder weather and thus a higher steam demand, additional trials were conducted on four consecutive days, with the results shown in the following table:

Day	No. 6 / Additive / No. 2	# Steam	S:F	% ±	Additive:No. 6
1	3310 / 0 / 0	389,860	117.78	n/a	n/a
2	3120 / 3.5 / 3.5	423,180	135.63	12.07	1:891
3	3280 / 2.5 / 2.5	450,230	137.27	13.12	1:1312
4	3420 / 0 / 0	413,980	120.69	n/a	n/a

Because the baseline data can vary with the weather, and a 5% variance is possible on any given day (based on the weather and different inefficiencies in different loads), I undertook further testing in March of 2004, using as a comparison or control a day in February of 2004 having the closest fuel consumption. In the following table, the testing date is given an "m/dd" and the control date is "m/ddC."

Date	No. 6 / Additive / No. 2	# Steam	S:F	% ±	Additive:No. 6
3/16	4050 / 1 / 1	492,260	121.55	-0.99	1:2025
2/24C	4070	500,000	122.85		
3/17	4010 / 4 / 4	545,350	136.00	+1.79	1:1002
2/11C	4020	536,910	133.56		
3/18	3930 / 6 / 6	522,240	132.89	-1.8	1:655
2/17C	3910	529,140	135.33		
3/19	2910 / 5 / 5	374,430	128.67	-1.61	1:582
2/13C	2970	388,410	130.78		

3/22	3420 / 3 / 3	524,240	153.29	+10.03	1:1140
2/18C	3510	484,100	137.92		
3/23	3880 / 2 / 2	490,650	126.46	-2.16	1:1940
2/19C	3900	504,060	129.25		

5. In the foregoing tests, our existing measuring devices were used. The pounds of steam was determined using a Kent Taylor brand orifice plate, and the amount of fuel was measured using a Trident brand meter (wobble plate type).
6. Based on the foregoing tests and conditions, it is my opinion that a fuel savings of about 10% is achieved using the additive in a ratio between about 1:900 and about 1:1300 with respect to the amount of No. 6 oil.
7. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Jamie Ryder
Jamie Ryder

7/28/04
Dated

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Improve Suspended Water Removal from Fuels: A better understanding of molecular forces enhances free water separator selection (Reprinted from Hydrocarbon Processing)

A better understanding of molecular forces enhances free water separator selection

R. L. Brown, Jr., and T. H. Wines, Pall Corp., East Hills, NY

Reprinted from *Hydrocarbon Processing*®, December 1993.

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Webmaster's Note

Webmaster's Note:

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Δ Delta μ mu ρ rho σ sigma

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Introduction

Molecular forces, such as interfacial tension (IFT), viscosity, relative density and temperature, control water removal from fuel/water mixtures. A better understanding of these physical properties will aid in investigating separation techniques. Equations and case histories review several free water removal methodologies such as salt driers, liquid/liquid coalescers, etc., and their effectiveness on emulsion

surfactant-containing streams.

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A big problem

Today, water contamination in refinery fuels can be a bigger problem than solids contamination. It corrode and plug engine parts and is a significant contributor to tank bottom corrosion and bacteria. In addition, water may contain corrosive materials like chlorides that will cause equipment damage. It doesn't take much water to cause a problem. Water concentrations as low as 100 ppm can cause off-specification due to haze, color or overall water concentration. Detergents and additives that make water removal more difficult because they lower the interfacial tension between water and oil.

Field tests conducted at two refineries show how a stacked coalescer/sePARATOR configuration with medium outperforms salt driers in terms of total water removal from diesel fuel and do not disarrange (i.e., to coalesce) when exposed to surfactants like conventional glass fiber coalescers.

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Difficult to remove

Two forms of water can be present in fuels: dissolved or suspended as tiny droplets that range in size from 0.1 μm to 10 μm in diameter. This size is so small that it cannot be visually detected except when concentrated haze is formed. The free water is suspended as an emulsion. The more stable the emulsion, the more difficult it is to remove the water. Factors that affect water removal from a water/fuel mixture include interfacial tension, viscosity, relative density and temperature.

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Interfacial tension

The ability to remove water improves as the IFT between the two phases increases. The IFT (σ) is a measure of the attraction force between each phase for its own species. At a two-liquid interface, a natural surface tension is created as each phase is repelled by the other phase. A ring-pull method is used to measure IFT. This method measures the force required to pull a platinum-iridium ring of circumference from one discontinuous phase into the next. The typical units of IFT are dyne/cm. IFT is a critical factor when considering liquid/liquid coalescence because the largest possible stable droplet size that can form by the coalescence process will be dictated by IFT. A system with a high IFT (i.e., $\sigma > 20$ dyne/cm) will sustain a larger stable coalesced droplet size, which can be easily separated. Systems with a low IFT (i.e., $\sigma < 20$ dyne/cm) will form smaller stable coalesced droplets and require high energy separators. Besides IFT, the coalesced droplet size will also depend on the system dynamics including relative droplet velocity, density and viscosity.

One method for correlating drop size to flow conditions has been developed by Hu and Kintner.¹ The drag coefficient (C_d) of different organic drops in water is related by a physical property group (P) and Weber number (We) over a range of Reynolds numbers (Re). A unique curve is produced when $C_d * We$ is plotted against $Re/P^{0.15}$ where

$$C_d = \text{Drag coefficient} = 4gd \Delta \rho / 3 \rho_0 V^2$$

$$P = \text{Physical property group} = \rho_0^2 \sigma^3 / g \mu_0^4 \Delta \rho$$

$$We = \text{Weber number} = V^2 d \rho_0 / \sigma$$

$$Re = \text{Reynolds number} = \rho_0 V d / \mu_0$$

$$V = \text{Terminal velocity}$$

$$d = \text{Droplet diameter}$$

$$g = \text{Acceleration due to gravity}$$

$$\rho_0 = \text{Density of continuous phase}$$

$$\mu_0 = \text{Viscosity of continuous phase}$$

$$\Delta \rho = \text{Density difference between droplet and continuous phase}$$

σ = Interfacial tension

Conventional coalescers can work effectively on mixtures with an IFT no lower than 20 dyne/cm. Factors that reduce IFT, and make coalescing more difficult, include using surfactant-containing inhibitor additives with the fuel. In addition, solid contaminants also lower the IFT. Refined fuels that contain water may have an IFT of 10 dyne/cm or lower.²

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Viscosity

Liquid media viscosity has a significant impact on the coalescence process. The two droplets must move through the liquid and collide. The next step is fusion of the two droplets, which requires the breaking of the liquid/liquid interface between the droplets. Both steps in the coalescence mechanism are impeded by higher viscosity. The droplets must overcome a higher drag force to reach one another. The breakdown of the liquid/liquid interfaces to create larger fused droplets is made more difficult by a higher viscosity if the droplets are larger. More residence time is required to accomplish the same coalescence level compared to a lower viscosity. This can be done by either lowering the flowrate or increasing the coalescer medium's area.

The ΔP across the coalescer will also be affected by viscosity:

$$\Delta P = K\mu Q$$

where

Q = Flowrate

μ = Viscosity

K = Medium constant (coalescer).

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Relative density

The relative density between the two phases to be separated (e.g., water from gasoline) can have a significant effect on coalescer performance. As the density of the coalesced liquid to be removed approaches the density of the liquid's density, separation becomes more difficult.

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Temperature

The fuel/water mixture's temperature can also affect separation efficiency. As temperature increases, the water droplets' size decreases, lowering the water droplets' size. In addition, fuels saturated with water at high temperatures contain a high concentration of dissolved water, which cannot be removed by liquid/liquid coalescing. As temperature decreases, the water falls out of solution into a suspended state and can then be removed by the liquid/liquid coalescer.

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Surfactants -- double trouble

Not only do surfactants reduce coalescer efficiency by lowering the IFT, they also disarm the coalescer, which is one of the biggest operational problems. When a liquid/liquid coalescer is operating inefficiently, water molecules bond with the silanol functional group (Si-O-Si) of the glass fiber. The silanol groups that collect on the glass fiber coalesce with incoming water molecules to form larger droplets. These droplets eventually become heavy enough to drain from the coalescer. In an inefficiently operating coalescer, the silanol groups that have fallen from the silanol functional group, the coalescing process repeats (Fig. 1).

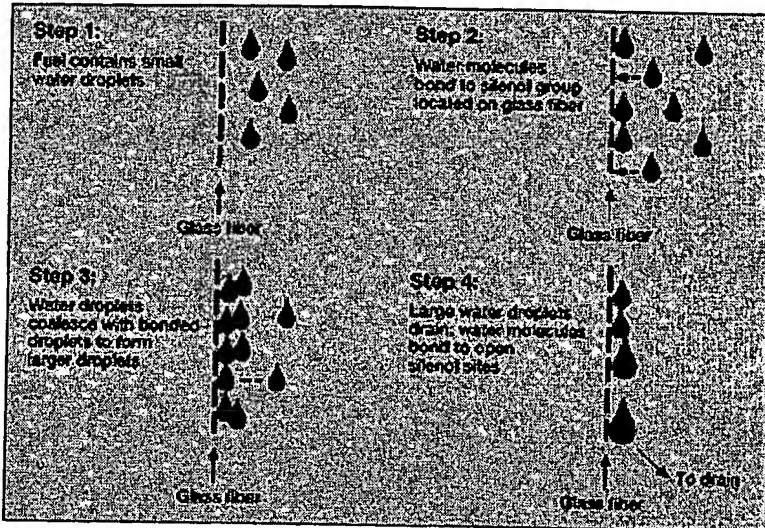
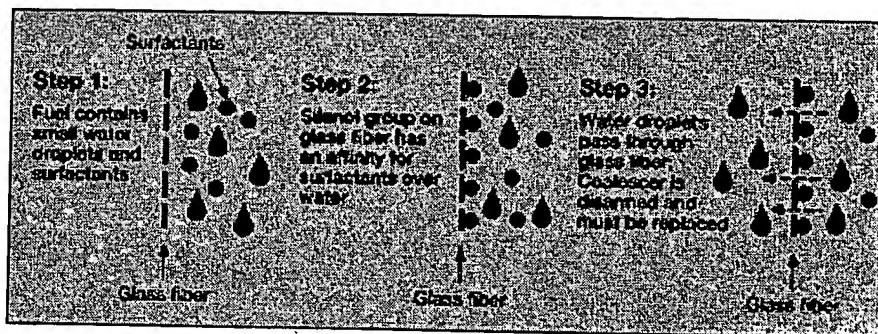


Figure 1. Simplified mechanism for effective coalescing.

Disarming occurs when surfactants bond with the silanol functional group. The silanol group has for surfactant molecules than for water. As the surfactant bonds to the glass fiber medium (Fig. 2). This process greatly reduces water removal effic the probability of water breakthrough and shortening the coalescer's service life. Result: frequen and increased disposal cost of coalescer cartridges.



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Other water removal technologies

Conventional technologies used to remove water from fuel include:

- Tank settling, which may be unreliable and take several days, an unacceptable amount o the water effectively
- Sand filters, which have high capital costs and may not always be efficient
- Salt driers, which experience temperature sensitive operational problems and can add co to the fuel.

A fuel stream may go through one or more of these methods to meet a refinery's haze or moistur

Some problems experienced with salt driers include bridging, which results in poor overall usage 50%)⁴ of the salt and channeling, which is large hole formation throughout the length of the drier. caused by high flowrates and poor distribution through the drier. Maintenance problems such as occur at lower temperatures.⁶ In addition, any water that remains in the fuels after it flows through will contain chlorides, which can result in corrosion problems downstream in tanks, piping and ec drier efficiency is best when operated within a relatively low temperature range and at a steady fl salt driers can remove dissolved water where coalescers may only remove free or suspended wa

However, liquid/liquid coalescers should have the advantage of removing free water from hydroc continuous and reliable basis. They should not add any potentially corrosive materials to the fuel

removal efficiencies and relatively low capital and operating costs. Liquid/liquid coalescer can operate at fluctuating flowrates and temperatures.

Better stream preparation improves downstream coalescing. A newer design uses a filter stage to remove particulates and has a stacked coalescer/separator configuration with polymeric medium to improve distribution and overcome disarming (Fig. 3). This design results in improved reliability and lower costs (Table 1).

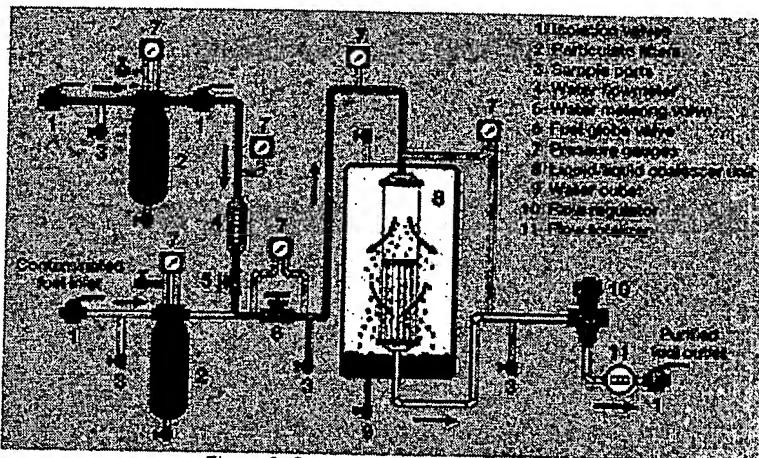


Figure 3. Stacked coalescer/sePARATOR.

Table 1. Estimated operating costs of stacked coalescer/sePARATOR system for different fuels

Fuel	Viscosity, centistokes 100°F	Operating costs, ¢/gal
Gasoline	0.7	0.015
Jet A	1.6	0.023
Jet B	2.3	0.024
Diesel (2-D)	3.5	0.032
No. 2 Fuel oil	3.6	0.033
No. 4 Fuel oil	8.5	0.067

*Assumes a 20,000-bpd flowrate.
Includes both filter and coalescer/sePARATOR stack replacement costs.
Does not include initial capital and installation costs.
Filters sized at 0.5 gpm/ft² and changed out eight times/year.

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Laboratory tests

Tests conducted at an independent laboratory on unleaded gasoline used a stacked coalescer/sePARATOR system. The test protocol closely followed API 1581 Jet Fuel Separator qualification and specifications.⁷ The unleaded gas mixtures charged to the test unit was 3 dyne/cm to 7 dyne/cm. A finely divided water-in-oil emulsion was used to challenge the coalescer. Free water concentration in the inlet mixture was 1 ppm to 3% (30,000 ppm) by volume. In all test cases, the effluent concentration of free water after passage through the coalescer was less than 15 ppm by volume.

Testing also demonstrated the limitations. The coalescer stage size is limited by ΔP and by the coalescing mechanism. Design flow through the coalescer is inversely proportional to the viscosity in cSt. Results showed that a 20-in. long coalescer (3-3/4 in. diameter) can handle a flowrate of 30 gpm (viscosity = 0.7 cSt) for a clean ΔP of 5 psid. The same sized coalescer can handle 6 gpm of a 3.5 cSt fuel (viscosity = 3.5 cSt) when sized for equivalent pressure drop and water removal efficiency.

The separator is velocity limited and not adversely affected by increasing viscosity. Water breakthrough occurs within the separator once a maximum velocity or flowrate is reached. The design velocity for the available 20-in. separator is 30 gpm regardless of viscosity.

These stage limitations indicate that a larger coalescer stage with the same sized separator can handle higher flowrates for more viscous fluids. A 40-in. coalescer/20-in. separator, for example, can handle twice the flowrate of a 20-in. coalescer/20-in. separator. Because lower viscosity fluids like gas pass through the separator, a larger coalescer does not improve the flowrate per coalescer/separator stack.

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Field results

Field tests were conducted at two refineries on diesel streams. The water source in diesel can be steam stripper at the back end of a diesel hydrotreater. When the diesel exits the steam stripper, the water is dissolved. As the diesel cools, water drops out of solution into suspension. Because coalescers only remove suspended water, it is important to locate the coalescer in the coolest possible location.

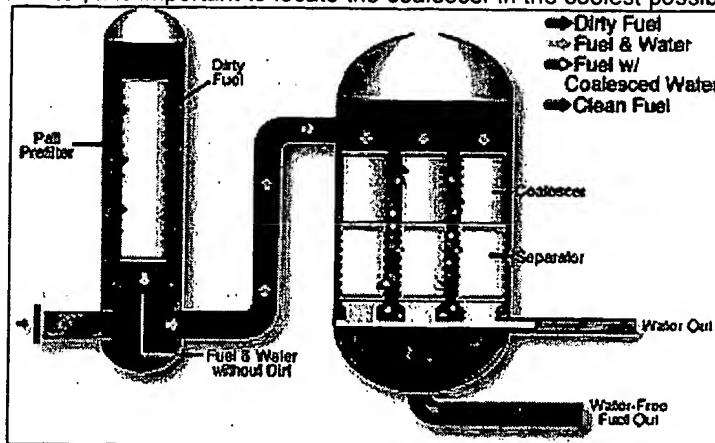


Figure 4. Liquid/liquid coalescer side-stream test stand.

Fig. 4 is a schematic diagram of the side-stream coalescer field test apparatus. It consists of a 3-in. prefILTER, a coalescer/separator stack enclosed in a glass filter housing, and associated valves and piping for pressure and temperature measurements. An inline flowmeter measured the stream's flowrate. The coalescer consisted of a 6-in. coalescer stacked on top of a 6-in. separator. Fuel samples were collected upstream and downstream of the coalescer for water content measurements.

Refinery A

At a major U.S. refinery, conventional diesel is prefiltered by 10 µm absolute filters, flowed to a salt (CaCl₂) tower for water and haze removal. In terms of haze, the salt drier at Refinery A was found to be minimal efficiency in haze removal when fluid temperatures exceeded 100°F. Haze temperature increased to approximately 10°F at temperatures around 75°F. After flowing through the salt drier, the diesel was filtered by 10 µm absolute filters to remove salt particles and other solids. Salt tower operation is expensive, requiring extensive maintenance due to salt pluggage and disposal. In addition, approximately 10% of the diesel that is processed through the drier is off-specification due to temperature-related haze.

Table 2 summarizes the test results. The diesel entering the test stand typically contained over 1 ppm water with an average haze rating of 6. Downstream of the stack, the free water contents were below 11 ppm. The filtrate samples for 1 gpm, 1.5 gpm and 2 gpm were bright and clear with an average haze rating of 1. At a flowrate of 3.5 gpm, a coalescer limitation was reached due to high differential pressure, and the average haze rating increased to between 2 and 3.

Table 2. Summary of test coalescer test results at Refinery A

Fluid: #2 Diesel
Viscosity: 3.5 cSt at 100°F
Fluid temp.: 97°F

Flow, gpm	Stack pressure drop, psid	Haze test*, coalescer inlet	Coalescer inlet free water, ppmv	Coalescer outlet free water, ppmv	Haze test* coalescer outlet
1	2	6	120	11	1

1.5	2	6	120	10	1-2
2	4	6	120	9	1
3.5	11	6	120	6	2-3

* based on Colonial Pipeline Co. "Line Chart" system.

The total water content of the samples collected at flowrates from 1 gpm to 2 gpm compared favorably to samples taken downstream of the salt drier (110 ppm collected at ~ 100°F). Operating costs analysis indicates a significant difference between the salt drier and the stacked coalescer (Table 3). Higher materials and disposal costs of the drier more than offset the incremental costs required for adding coalescer stacks. Use of the coalescer either in place of, or in conjunction with, a salt drier is being considered for refinery expansion.

Table 3. Comparison of operating costs between salt drier and stacked coalescer/separators system at Refinery A

Item	Incremental annual costs of operating coalescer
Filter usage	(\$24,000)
Coalescer usage	(\$36,000)
Salt (includes maintenance, material and disposal)	\$240,000
Total	\$180,000*

* Does not include benefits resulting from reducing amount of off-test product, which is currently 4% of the diesel run through this drier.

Refinery B

A medium-sized U.S. refinery removes water from diesel with a horizontal separator and an NaC drier. During the warm weather months (May to September), the diesel has occasional haze problems due to additional drying. Refinery B's quality check is called the haze clear-up temperature, which involves heating the diesel until a stable haze appears and then slowly reheating it until the haze disappears. The temperature at which the sample starts to clear is recorded as the haze clear-up temperature. The lower the haze clear-up temperature, the drier the sample.

Test results are summarized in Table 4. The diesel entering the test stand typically contained over 4 ppm free water and was rated as hazy and cloudy. Effluent samples of the coalescer were bright and clear with water concentrations ranging from 4 ppm to 6 ppm. The effluent samples' haze clear-up temperatures measured by Refinery B, ranged from 68°F to 81°F. Typical haze clear-up temperatures of salt-driers range between 90°F to 100°F, well above the specification of the Colonial Haze test of 70°F.

Table 4. Summary of test coalescer test results at Refinery B

Fluid: #2 Diesel
Viscosity: 4.0 cSt at 100°F
Fluid temp.: 98°F

Flow, gpm	Stack pressure drop, psid	Coalescer inlet free water, ppmv	Coalescer outlet free water, ppmv	Haze clear-up temp., °F	Coalescer Drier
0.5	1	150	*	*	95
1	2	150	4	81**	95
1.5	3	150	6	68**	95
2	4	150	6	68**	95

* Not measured for this run.

** Visual test was "bright and clear."

Field test results indicate that the water removal performance of the newer liquid/liquid coalescer compares to a salt drier and may be used in place of, or in conjunction with, a salt drier to get effective water removal from refinery fuels, as well as reduce maintenance and operating costs.

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References

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